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Volume 28, Pointing Performance for the SeaWiFS Mission

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ABSTRACT

The onboard pointing performance of the OrbView-2 (OV-2) spacecraft for the first five years of the SeaWiFS mission is presented. Adjustments to the onboard attitude control system (ACS) since launch are described, and various issues and anomalies regarding the performance are discussed. Overall, this relatively low-cost spacecraft has performed quite effectively after various in-flight adjustments, however, a variety of sensor and computational anomalies have caused occasional minor pointing disturbances. Many of these disturbances have implications for the navigation processing performed for the science data by the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Project at the NASA Goddard Space Flight Center. Possible further adjustments to the OV-2 ACS have been investigated which could lead to improved pointing performance, and conclusions from these analyses are presented. Some of the various sensor and software anomalies are fairly well understood, but some others remain puzzling. Particularly vexing are various timing anomalies resulting from the way the clocks for three separate onboard processors are synchronized to each other and Global Positioning System (GPS) time. The pattern of occurrence of some of the sensor anomalies could merit further review and trending, which may be useful to monitor for any degradation in performance as the mission continues.

1. INTRODUCTION

The pointing control of the OrbView-2 (OV-2) spacecraft, which was built and launched by Orbital Sciences Corporation (OSC) and operated by OrbImage, has been adjusted in a number of major and minor ways since launch. The adjustments have been made to onboard tables, or in a few cases, via an onboard software patch or *poke*. The main goal has been to minimize control disturbances so that ground-computed attitudes can generally meet the accuracy requirements. A variety of sensor and onboard computational anomalies have been recognized, which occasionally contribute to onboard attitude errors and resulting pointing disturbances.

This report documents the onboard pointing and adjustments, the pointing stability of the spacecraft, and various anomalies. The following introductory sections present relevant background material about the spacecraft, the orbit, and data availability. Section 2 discusses the onboard attitude estimation and its errors, and adjustments made to improve the performance. Section 3 discusses the overall pointing stability in terms of the dynamics, disturbance sources, control responses, and control adjustments. Section 4 describes various anomalies, and Sect. 5 presents a discussion of key results and lessons learned.

1.1 Spacecraft Description

The OV-2 spacecraft (originally called SeaStar) is illustrated in Fig. 1. The single-imaging instrument—the Sea-viewing Wide Field-of-view Sensor (SeaWiFS)—is at the bottom of the structure, as shown in the nominally Earth-nadir pointing direction. Deployed solar array panels are at the top. The nominal flight direction is roughly into the page, so that the solar diffuser scope, on the left of the SeaWiFS instrument, and the back panel (shown with numerous boxes) face away from flight.

1.1.1 Coordinates and Attitude Angles

The attitude control system (ACS) coordinates used in this report are shown in Fig. 1 with respect to the spacecraft structure†. The ACS $\vec{X}$, $\vec{Y}$, and $\vec{Z}$ axes are also referred to as the roll, pitch, and yaw axes, respectively. When roll, pitch, and yaw are referred to as angles, they represent rotations about these axes from the nominal flight orientation: $\vec{X}$ is along the general direction of orbital motion, $\vec{Y}$ is opposite to the orbit normal direction, and $\vec{Z}$ is toward the nadir. The order of rotation, i.e., pitch–roll–yaw, is applied when computing the angles for the estimated attitude.

Sensor and actuator orientations are described in this document relative to these ACS axes, henceforth referred to as $\vec{X}$, $\vec{Y}$, and $\vec{Z}$.

1.1.2 ACS Overview

Being a relatively low cost mission, the OV-2 spacecraft does not carry instruments which are used for very accurate onboard attitude determination, such as, a gyroscope or star tracker. Instead, the spacecraft relies on alternative instrumentation: the two-axis digital sun sensor (DSS), the Earth horizon scanner (HS), and the three-axis magnetometer (TAM). Stability is maintained by a single-momentum wheel, which provides gyroscopic inertia along the pitch axis, $\vec{Y}$. The wheel speed is varied to control pitch, while roll, yaw, and the total angular momentum are adjusted by magnetic coil (torque rod) interactions with the Earth's magnetic field. This control is described in more detail in Sect. 3.

† The labeling for these axes is different than that used for the ground data processing (Patt 2002) for the SeaWiFS base (and also used elsewhere for OV-2 spacecraft and SeaWiFS instrument coordinates), where S_x is the axis normally along the geodetic nadir, S_y is the axis normally opposite the velocity direction, and S_z is the axis normally toward orbit normal. The definitions of roll, pitch, and yaw are nevertheless equivalent in the onboard and ground computations.